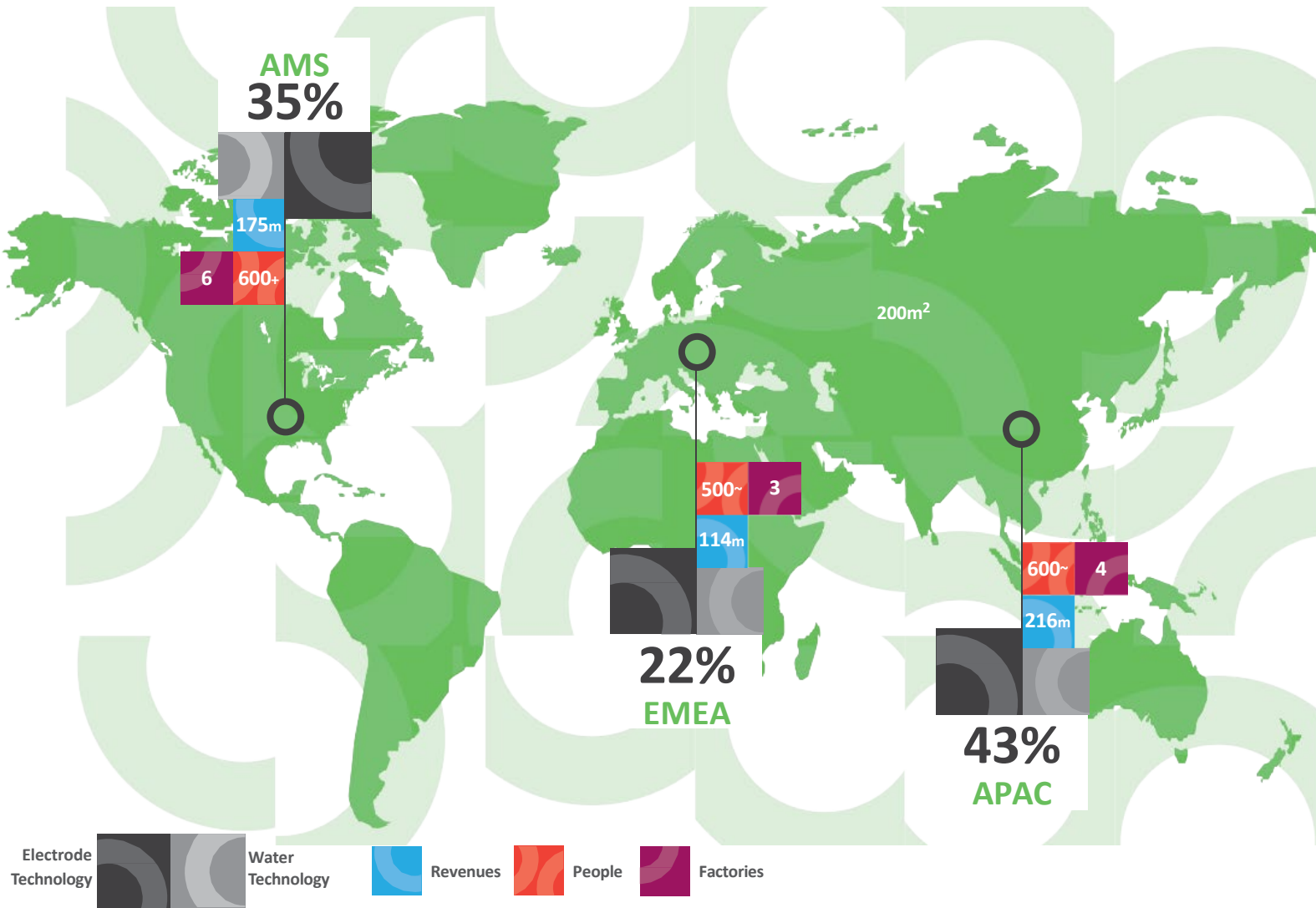




# Electrochemistry, Water, Energy: our future for the World

US Dept. Of Energy Hydrogen Energy Earth Shot Summit  
September 1<sup>st</sup>, 2021



- Global reach complemented by local presence to better serve our customers
- Long-term relationships with our customers built on years of cooperation
- Largest installed base of insoluble electrodes & 10,000+ water systems worldwide
- Strong focus on innovation
- Well invested, state-of-the-art facilities optimized for future growth

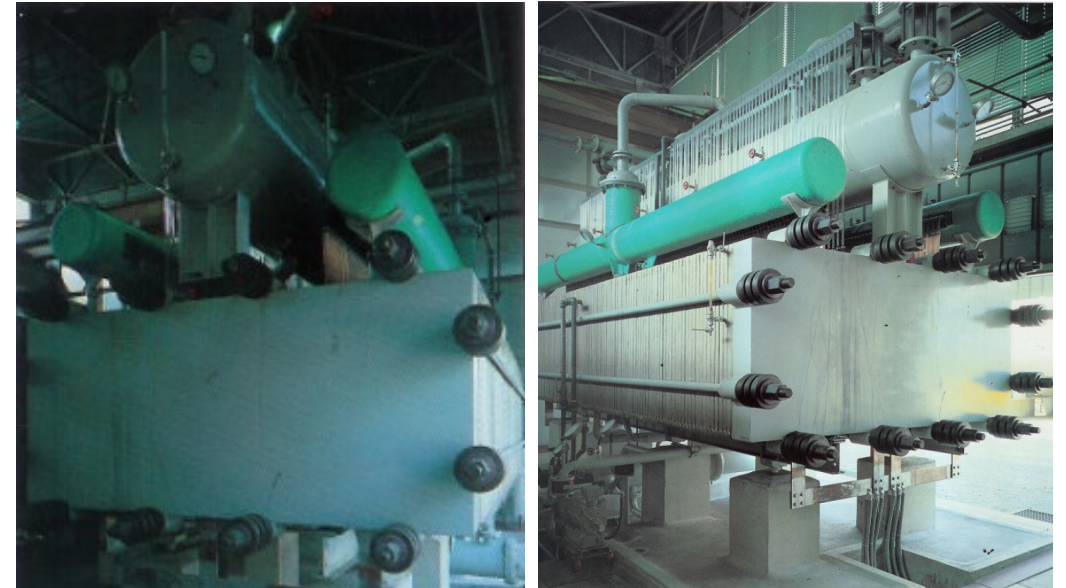
**Family owned Italian Company, founded in 1923, based in Milan**

A legacy of success thanks to technological breakthroughs that keep revolutionizing modern electrochemistry thanks to a strong commitment to innovation, targeting sustainable growth thanks to continuous improvement.



# De Nora first entered the AWE business in 1957...

- Overall installed capacity:  
    > 33,000 Nm<sup>3</sup>/h (150 MW) between 1957 and 1994
- Largest installed capacity: 25,000 Nm<sup>3</sup>/h (112 MW) –  
    The Fertilizer Corporation of India, New Delhi (1959)
- Bipolar stack design
- Well integrated Stack and BoP (reduced plant footprint)
- Double diaphragm technology
- DC electric energy consumption: 4.5 kWh/Nm<sup>3</sup> of hydrogen



Brochure from late 80's

AWE business progressively lost importance, starting from the 60s, because steam methane reforming was deployed for the large-scale hydrogen production in the chemical and petrochemical industry.

**De Nora re-started R&D activities on water electrolysis in 2013 targeting a new generation of alkaline water electrolysis able to work at much higher current densities but with lower specific power consumption.**

# De Nora's offer for modern Alkaline Water Electrolysis



## Electrodes

Anode and cathode advanced electrodes coated with proprietary catalytic coatings, able to reduce WE specific power consumption and to run at high current density

- Proprietary electrode technologies designed to operate in a large range of conditions - capex & opex optimization
- **Main Strengths:** reduction of power consumption and plant footprint, increase of efficiency and hydrogen quality

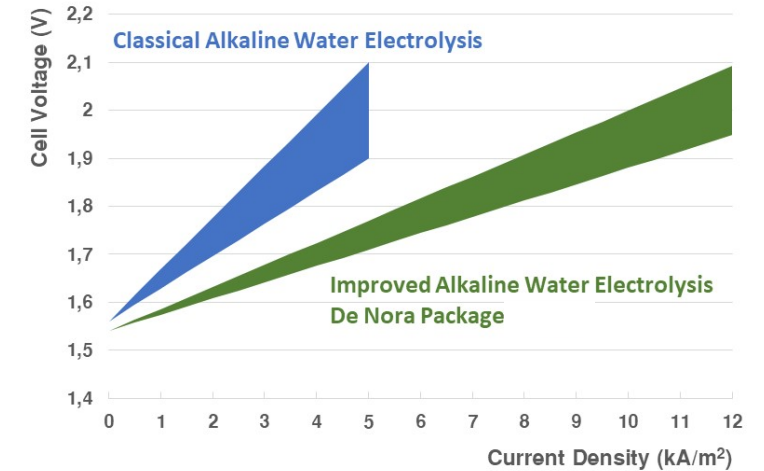
The new generation **AWE 2.0** is able to reach up to **80% efficiency @ 10 kA/m<sup>2</sup>** (ref. HHV) - but current density can be pushed up to 12 kA/m<sup>2</sup> – becoming a **viable alternative to steam methane reformer (SMR)**

## EPC capabilities

Our JV tkUCE has EPC capabilities and the knowledge in managing large plant construction projects.

tkUCE has its own AWE technology that is always equipped with De Nora electrodes.

**De Nora is the only owner of intellectual property rights about electrodes and catalytic coatings. We are positioned to serve all WE OEMs.**



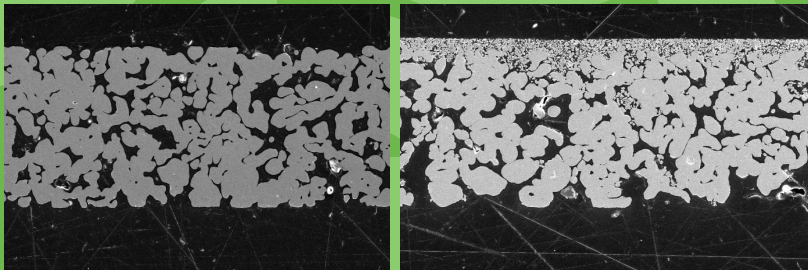
AWE Stacks – courtesy of tkUCE and McPhy

## Strong knowhow on...

- Gas diffusion electrodes, deriving from our long experience in fuel cells (Nuvera, ETEK™).
- Electrocatalysts (platinum, iridium and low-PGM alloys), largely deployed in many applications for oxygen and hydrogen evolution reactions.

### De Nora Anode PTLs

Catalyst / Membrane side



Flow field / BPP Side

## Our goal

Leverage our experience in electrocatalysis, GDE electrodes, and titanium metallurgy to develop new catalysts and electrode architectures that reduce or eliminate iridium use, help enable thinner membranes, and reduce overall manufacturing costs

## Our capabilities

- Internal research & development centers for catalyst synthesis, coating development, and electrode testing
- Fabrication and testing of MEAs at the developmental scale (US and Japan)
- Industrial GDE electrodes manufacturing (Germany) - 15,000+ m<sup>2</sup>/year capacity



EXCITING

SUSTAINABILITY

 DE NORA

PARTNER OF CHOICE

CONTINUAL IMPROVEMENT



*discover more*



# The Chemours Company Introduction

## Nafion™ Materials for the Hydrogen Economy

Andrew Park, Ph.D  
R&D Principal Engineer  
Hydrogen Shot Summit  
September 1, 2021

# Chemours' Businesses and Nafion™



**Industry Leader** in safe production and manufacture of performance chemicals, combining leading products, applications expertise, and market-shaping chemistry



- Leading brand of perfluorosulfonic acid (PFSA) polymers for ion-conducting applications
- Invented in the 1960s, commercialized in late 1970s at Fayetteville, NC plant
- Chemours is the sole manufacturer of the Nafion™ brand of ion exchange materials



“ Chemours is thrilled to join the Hydrogen Council and to help realise the potential of hydrogen's important role in the global energy transition. With expertise and scientific know-how, companies like ours are helping make a cleaner, greener tomorrow a reality. ”

**Mark Vergnano**

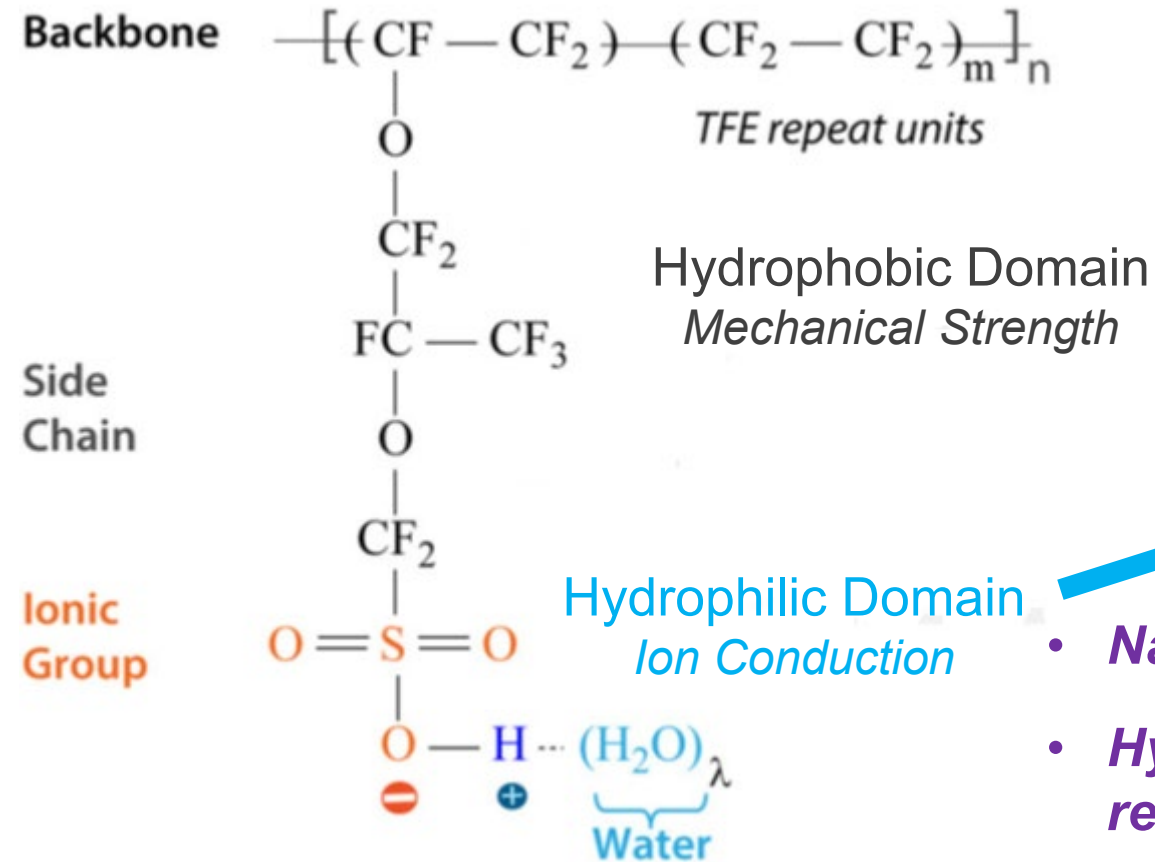
*Former President and CEO, Chemours*



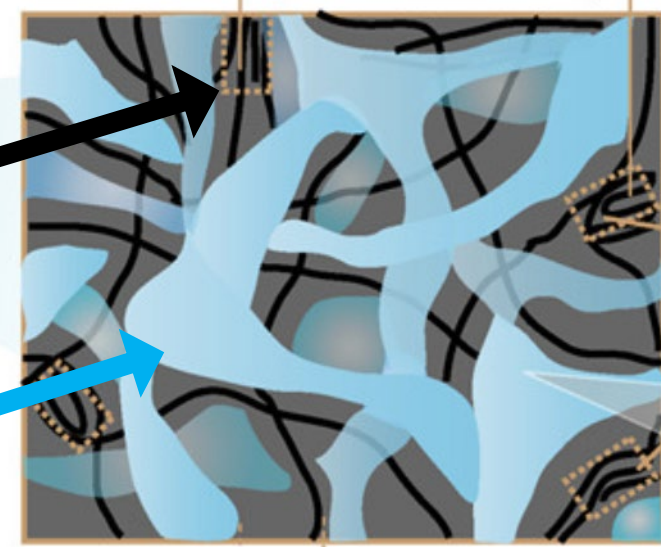


# Nafion™ Polymer Chemistry: Unique Morphology Enables Proton Conduction

## Nafion™ Polymer Chemistry



## Nafion™ at the Nanoscale: Phase Separated Morphology



- Nafion™ is a proton conducting polymer electrolyte
- Hydrophobic domains provide a durable, mechanically reinforcing “backbone”
- Hydrophilic domains enable a proton conducting “highway” throughout the polymer matrix

# Nafion™ Product Portfolio: Enabling the Hydrogen Economy

## Nafion™ Membranes

Product Name	Thickness (µm)
NR211	25
NR212	50
N113	80
N115	127
N117	183
N1110	254

## Nafion™ Dispersions

Product Name	Solids (%)
D520/2020	5 / 20
D521/D2021	5 / 20

Chemours is **backward integrated** in the manufacture of Nafion™ membranes and dispersions.

Chemours has the **polymer capacity** to manufacture Nafion™ membranes in large scale.



- Chemours has >40 years' experience in the commercial manufacture of Nafion™ ion exchange materials
- Chemours has established a Global Venture Team solely focused on the development of materials used in the Hydrogen Economy, enabling our customers to achieve their business objectives.
- Multiple new product development programs in progress for membranes and dispersions in hydrogen applications

# Nafion™ Research Activity and Collaborations: Progressing Toward \$1/kg Hydrogen

- Chemours has recently completed the Chemours Discovery Hub - a 312,000 sq ft facility dedicated to R&D in Newark, DE.
- Chemours believes new advancements in Nafion™ polymeric materials are **critically enabling** for \$1/kg H<sub>2</sub>.
- Chemours leads or participates in three Department of Energy projects under two initiatives related to materials development within the hydrogen economy space, including:
  - Water electrolyzer membranes
  - Fuel cell membranes
  - Advanced ionomers for catalyst layers
- Chemours is committed to a multigenerational R&D plan to ensure the success of the hydrogen economy and the Earthshot goal of \$1/kg H<sub>2</sub>.





Johnson Matthey  
Inspiring science, enhancing life

# Hydrogen Hotshot

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Peter Ellis

Johnson Matthey

# Strong credentials

Strong brand  
**200-year  
history**

Technology leadership  
**#1 or 2**  
in chosen markets

2019/20 sales\*  
**£4.2 billion**

2019/20 underlying  
operating profit  
**£539 million**



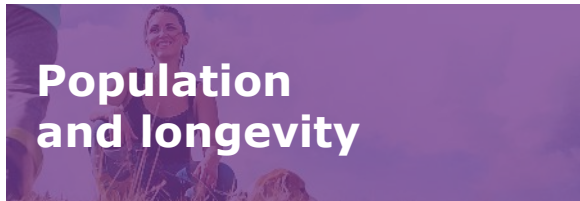
# Making the world cleaner and healthier



Climate change



Energy transition



Population and longevity



Resource challenges

**225,000 tonnes**

(CO<sub>2</sub> eq) of greenhouse gas avoided using our battery material and fuel cell technologies

**3m tonnes**

of pollutants removed by our emission control catalysts

**323,000 lives**

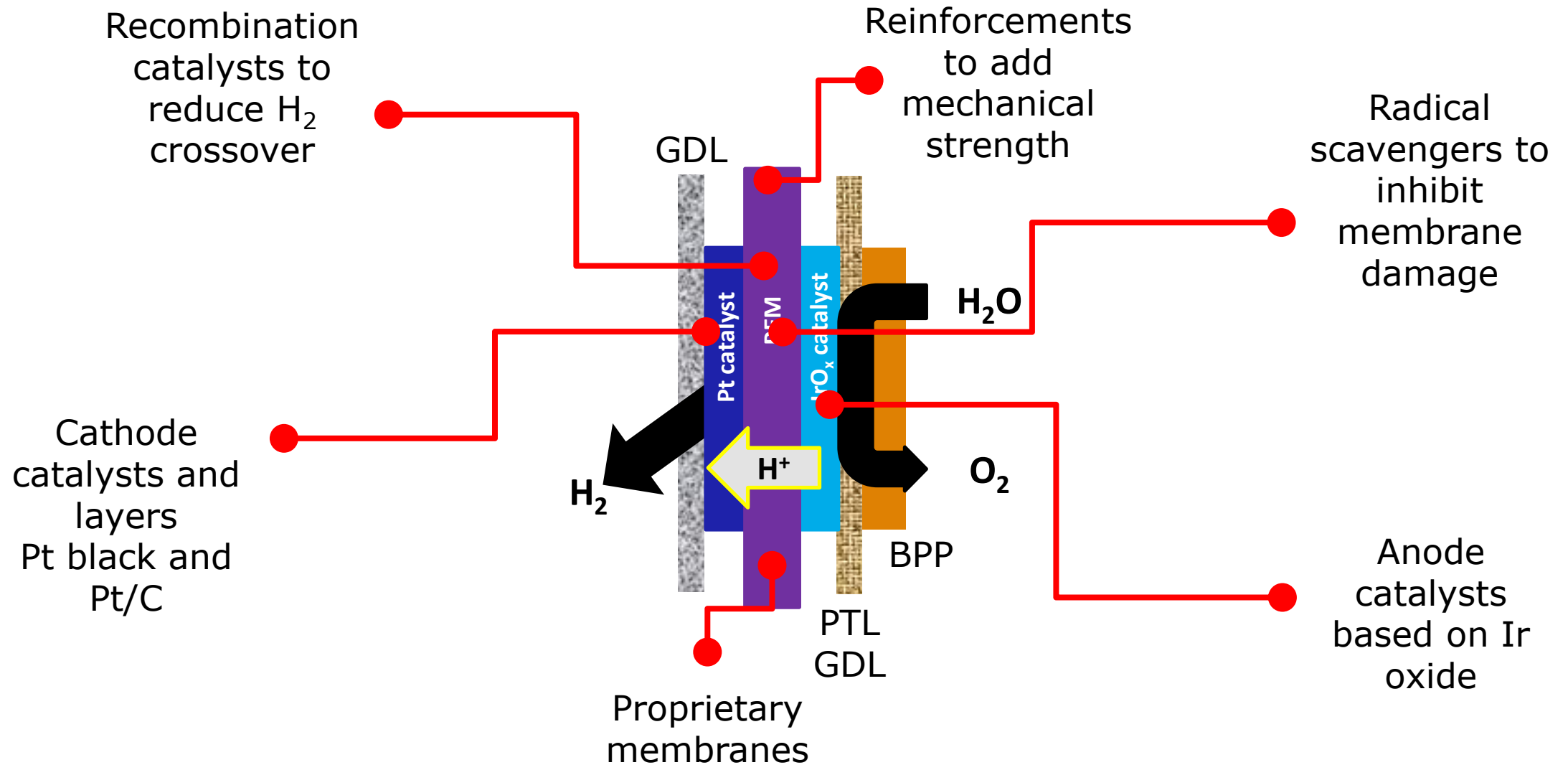
positively impacted as a result of recently launched drugs using our APIs

**10m tonnes**

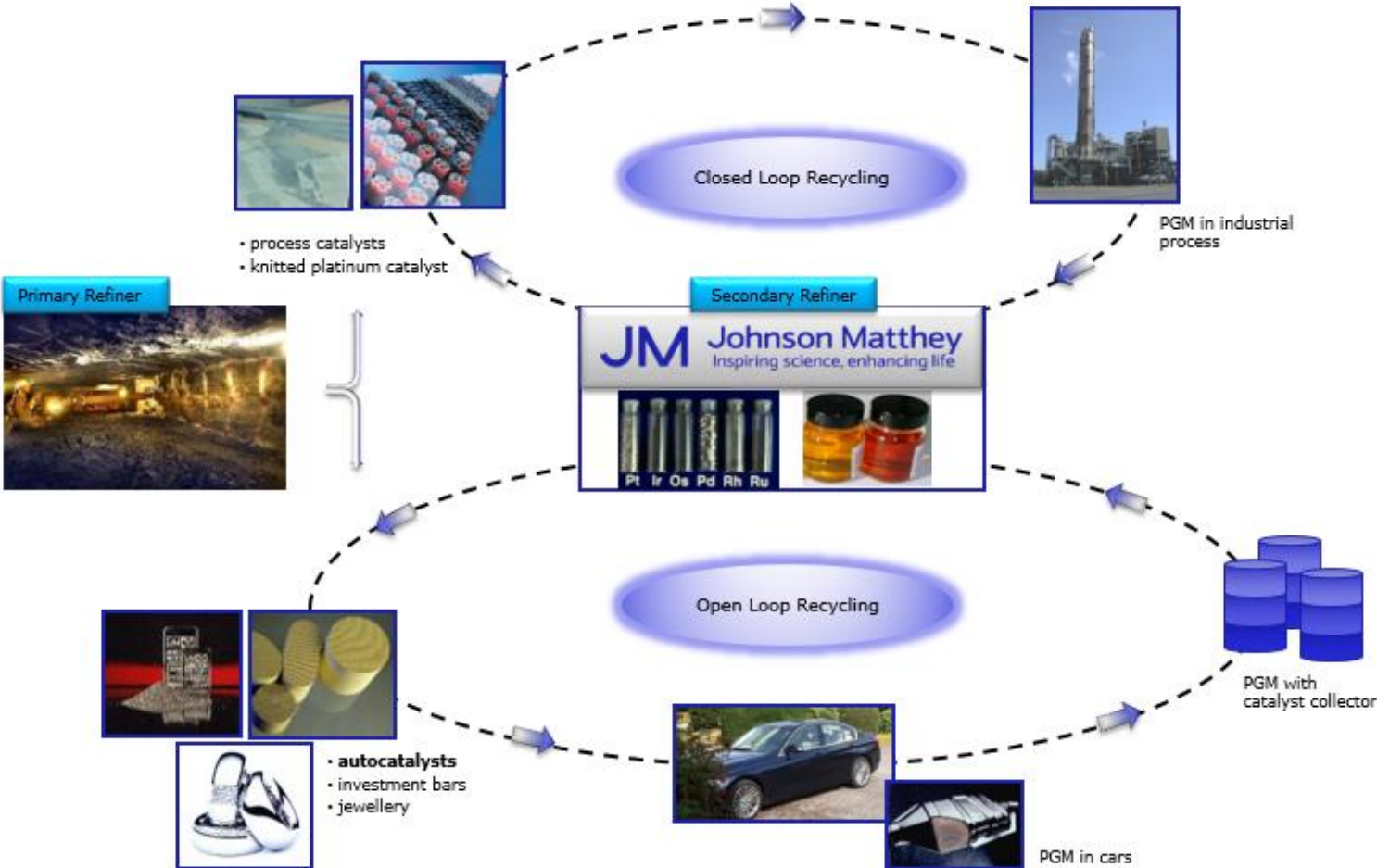
(CO<sub>2</sub> eq) of greenhouse gases removed using our nitrous oxide abatement technologies

**86% of sales contribute to the UN Sustainable Development Goals**

# JM is active in all aspects of the CCM



# Effective Management of Precious Metals will be key in the Success of PEM Electrolysis



Example of Process Catalysis

Example of Automotive Emission Control Catalysts



JM

Johnson Matthey  
Inspiring science, enhancing life



# PAJARITO POWDER, LLC

Electrocatalyst Products for  
Fuel Cells & Electrolyzers

Dr. Barr Zulevi, CTO and President  
[bzulevi@pajaritopowder.com](mailto:bzulevi@pajaritopowder.com)

3600 Osuna Road NE, #309  
Albuquerque, NM 87109 USA

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# Company Overview



9

9-year old company with established customers



Electrocatalyst products for Fuel Cell & Electrolyzer



Electrocatalyst products for PEM, AEM, & Alkaline Electrolytes



Only U.S.-based developer of electrolyzer catalysts



Intellectual Property (IP) portfolio: trade secrets and 30+ patents



Proprietary, patented manufacturing platform



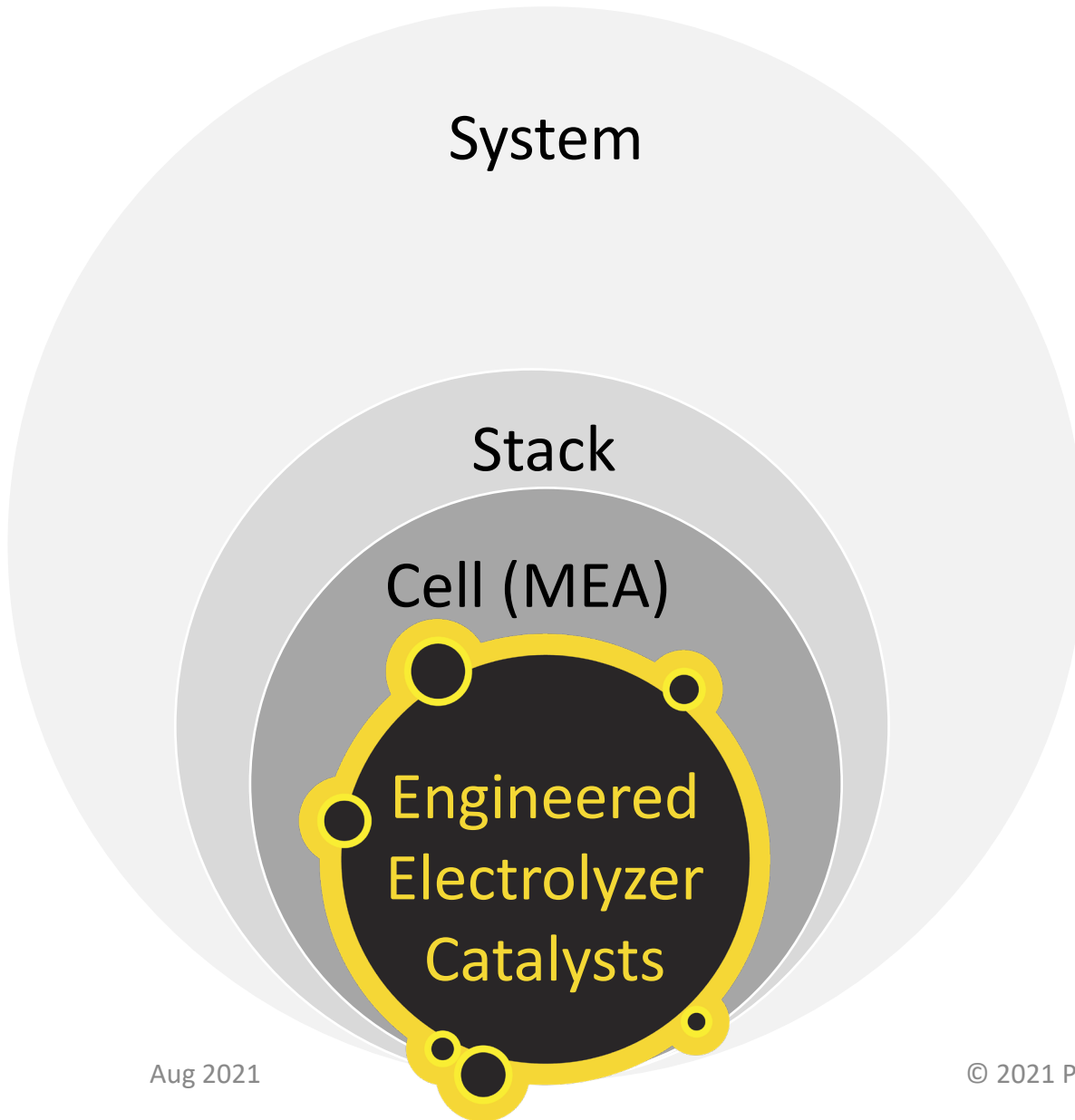
Product roadmap for electrocatalyst products



World-class technical team & advisory boards



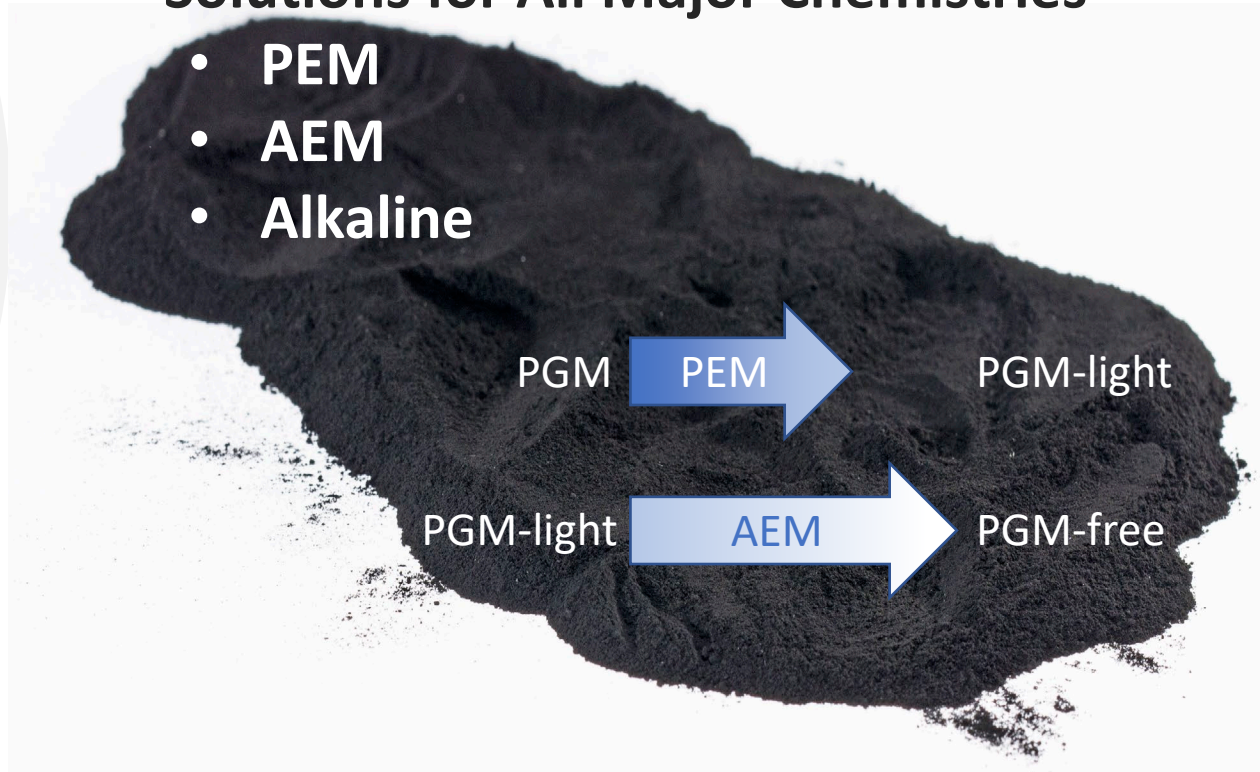
Sales to major systems developers and suppliers



## Engineered Electrolyzer Catalysts™

- Increase Power Density
- Reduce Precious Metal Use
- Solutions for All Major Chemistries

- PEM
- AEM
- Alkaline



# Investors: Private and Government Sources



## Private

Verge FUND

**HYUNDAI**  
MOTOR GROUP

*Omphalos Venture Partners*

## Angel Investors

### Contacts:

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[tstephenson@pajaritopowder.com](mailto:tstephenson@pajaritopowder.com)

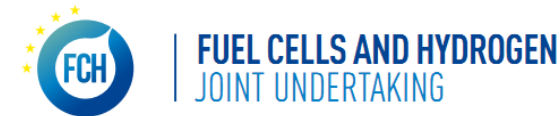
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## Government

- DOE Advanced Research Program Agency-Energy (ARPAE)
- DOE Office of Hydrogen Fuel Cell Technologies (HFTO)
- DOE Office of Fossil Energy and Carbon Management (FECM)



**NEW MEXICO** True  
**ECONOMIC DEVELOPMENT**